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ABSTRACT

It is necessary to identify nonstructural hazards at the school site to reduce the possibly of injury in the event of an earthquake. Nonstructural hazards can occur in every part of a building and all of its contents with the exception of structure. In other words, nonstructural elements are everything but the columns, beams, floors, load-bearing walls, and foundations. Common nonstructural items include ceilings, lights, windows, office equipment, computers, files, and anything stored on shelves or hung on walls. In an earthquake, nonstructural elements may become unhooked, dislodged, thrown about, and tipped over; this can cause injury and loss of life, extensive damage, and interruption of operations. Ever since the Field Act of 1933, public school buildings in California have been constructed to meet stringent seismic design codes; however, attention was not given to nonstructural hazards until relatively recently. Title 24 of the California Code of Regulations now prescribes some nonstructural seismic safety elements for new construction in public schools, but many nonstructural hazards are still not covered. A checklist gives the nonstructural hazards known to be dangerous or problematic in earthquakes. Illustrations contain the specifications necessary to correct the particular nonstructural hazard. (Author/KDP)

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ED 368 069

# IDENTIFICATION AND REDUCTION OF NONSTRUCTURAL EARTHQUAKE HAZARDS IN CALIFORNIA SCHOOLS

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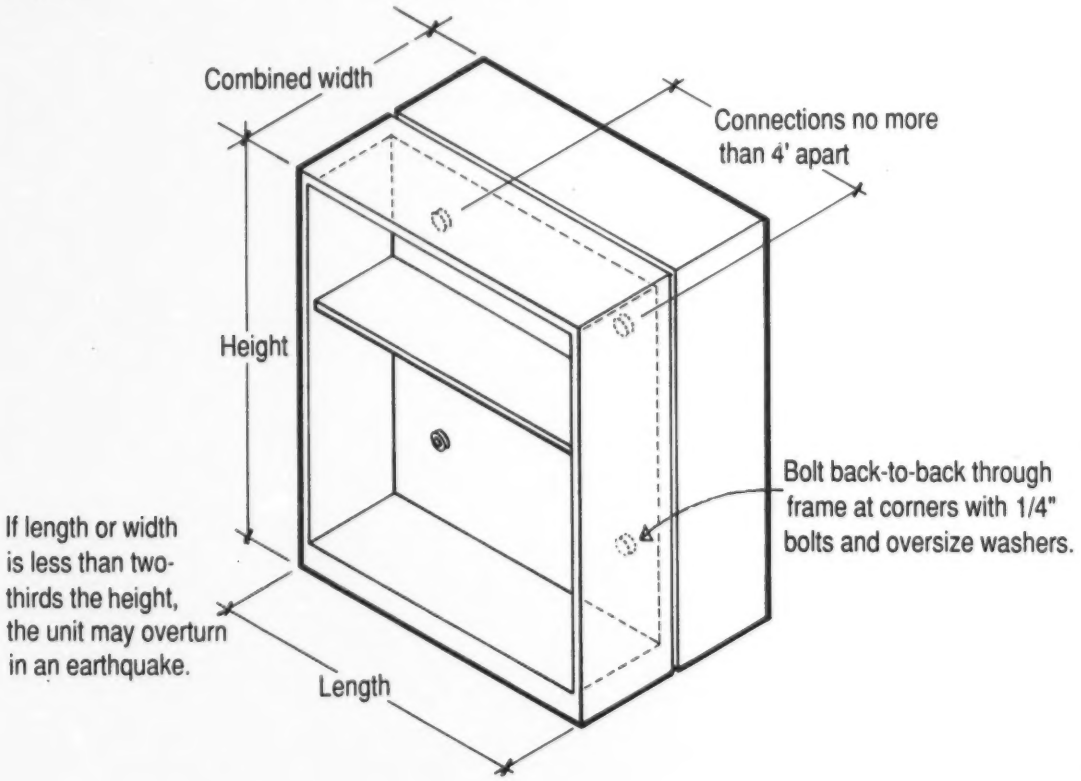
Combined width
Connections no more than 4' apart
Height
Bolt back-to-back through frame at corners with 1/4" bolts and oversize washers.
If length or width is less than two-thirds the height, the unit may overturn in an earthquake.
Length

Bay Area Regional Earthquake Preparedness Project
*A Project of the Governor's Office of Emergency Services*

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*Reprinted, 1991*

# IDENTIFICATION AND REDUCTION OF NONSTRUCTURAL EARTHQUAKE HAZARDS IN CALIFORNIA SCHOOLS

developed by

Bay Area Regional Earthquake Preparedness Project

and

Office of the State Architect

Structural Safety Section

February, 1990

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# NONSTRUCTURAL EARTHQUAKE HAZARDS

## INTRODUCTION

This publication is intended to help identify nonstructural hazards at the school site and to show how those hazards can be reduced. Nonstructural hazards can occur in every part of a building and all of its contents with the exception of the structure. In other words, nonstructural elements are everything *but* the columns, beams, floors, load-bearing walls, and foundations. Common nonstructural items include ceilings, lights, windows, office equipment, computers, files, air conditioners, electrical equipment, furnishings, and anything stored on shelves or hung on walls. In an earthquake, nonstructural elements may become unhooked, dislodged, thrown about, and tipped over; this can cause injury and loss of life, extensive damage, and interruption of operations.

Ever since the Field Act of 1933, public school buildings in California have been constructed to stringent seismic design codes; however, attention was not given to nonstructural hazards until relatively recently. Title 24 of the California Code of Regulations now prescribes some nonstructural seismic safety elements for new construction in public schools, but many nonstructural hazards are still not covered. Both public and private schools can make use of this publication to determine the extent of nonstructural hazards in their facilities.

The checklist on pages 2 through 4 contains the nonstructural hazards known to be dangerous or problematic in earthquakes. School administrators and engineers may carry the checklist with them as they survey a school site. After the survey is complete, any checked NO boxes represent hazards in need of correction.

In parentheses after each hazard listed there is either a brief solution or a numbered reference. The numbers refer to solutions on pages 5 through 18 that illustrate how to restrain or anchor nonstructural elements and thereby reduce their hazardousness. The illustrations contain the specifications necessary in order to correct the particular nonstructural hazard.

For some items the fix is fairly complicated, and **(A/E)** indicates that an architect or engineer should be consulted. **(LS)** after an item draws attention to the fact that it is a life safety hazard and should be a high priority for correction. Items in italics are generally already taken care of if they were part of recent state-approved construction in public schools.

This publication was developed jointly by staff at the Bay Area Regional Earthquake Preparedness Project (BAREPP), and the Structural Safety Section of the Office of the State Architect. An earlier BAREPP publication by Robert Reitherman, ***Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide***, was adapted to address specifically those nonstructural hazards most common in California schools.

Any questions about the use of this document should be directed to Dennis Bellet, Code/Research Engineer, at the Office of the State Architect in Sacramento, (916) 445-8730.

## CHECKLIST

*Use this checklist to complete a nonstructural hazards survey at a school site. Once the survey is completed, any checks in the NO boxes indicate items that are in need of correction.*

YES/NO

### EQUIPMENT AND FURNISHINGS

- ❑ ❑ Are desktop computers secured? (solution EF1a or b)
- ❑ ❑ Are the tops of tall (4- or 5-drawer) file cabinets secured to the wall? (solution EF2) **(LS)**
- ❑ ❑ Do file cabinet drawers have latches? (provide latches)
- ❑ ❑ Are large and heavy office machines restrained and located where they will not slide a few inches, fall off counters or block exits? (solution EF3a or b)
- ❑ ❑ Are wall-mounted objects over 5 lbs. connected to structural framing? (solution EF4)
- ❑ ❑ Are tall cabinets, bookshelves, coat closets attached to the wall or attached to each other? (solution EF5) **(LS)**
- ❑ ❑ Are desks or tables located such that they will not slide and block exits? (move them)
- ❑ ❑ Are tall storage racks cross-braced in both directions or, for racks significantly taller than wide, are there large anchor bolts connected to the concrete slab? (solution EF6) **(LS)**
- ❑ ❑ Are heavy or sharp wall decorations securely mounted, with closed eye-hooks, for example? (solution EF4)

YES/NO

- ❑ ❑ Are valuable, fragile art objects or trophies protected against tipping over, breaking glass or sliding off shelves or pedestals? (solution EF7)
- ❑ ❑ Are refrigerators or ranges restrained by built-in kitchen cabinetry or attachments to floor or wall? (solution EF2) **(LS)**
- ❑ ❑ Is floor-supported freestanding shop equipment secured against overturning or sliding? (solution EF8) **(LS)**
- ❑ ❑ Are fire extinguishers securely mounted? (solution EF9)
- ❑ ❑ Are potted plants or heavy items on top of file cabinets or other high locations restrained? (solution EF10)
- ❑ ❑ Are display cases or aquariums protected against overturning or sliding off tables? (solution EF1)
- ❑ ❑ Are weight room equipment and racks anchored and weights properly stored? (provide secured racks)
- ❑ ❑ Is freestanding equipment on wheels locked against rolling? (lock wheels)

### HAZARDOUS MATERIALS

- ❑ ❑ Are compressed gas cylinders secured top and bottom with a safety chain? (solution HM1)
- ❑ ❑ Are laboratory chemicals on shelves restrained? (solution HM2) **(LS)**

*(A/E) indicates an architect or engineer should be consulted. (LS) indicates a life safety hazard.*

*Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.*

YES/NO

- ❑ ❑ *Are gas tank legs anchored to a concrete footing or slab?* (solution HM3) **(A/E) (LS)**
- ❑ ❑ Are containers of hazardous materials stored on braced storage racks or tall stacks? (provide secured storage) **(LS)**
- ❑ ❑ Do gas pipes have flexible connections? (provide flexible connections) **(A/E)**

## OVERHEAD ELEMENTS

- ❑ ❑ *Does the suspended ceiling have diagonal bracing wires?* (solution OE1) **(A/E) (LS)**
- ❑ ❑ *Are the fluorescent light fixtures merely resting on the hung ceiling grid, without another support?* (solution EE1) **(A/E) (LS)**
- ❑ ❑ *Do pendant mounted light fixtures or chandeliers have safety cables?* (solution OE4) **(LS)**
- ❑ ❑ Will hanging light fixtures swing freely, not hitting each other if allowed to swing 45 degrees minimum? (fix or remove fixtures) **(LS)**
- ❑ ❑ Are decorative ceiling panels or latticework securely attached? (solution OE1)
- ❑ ❑ Will spotlights remain securely attached if shaken? (secure them)
- ❑ ❑ Are sound system speakers in elevated locations anchored to structure? (secure speakers)
- ❑ ❑ *Are suspended space heaters, especially gasfired, braced and/or have flexible gas connections?* (solution OE2) **(A/E)**

YES/NO

- ❑ ❑ Do hanging plants, mobiles, or displays have closed eye-hooks, and can they swing freely 45 degrees? (secure objects in safe locations, see solution EF4)
- ❑ ❑ Could chandeliers swing freely, not hitting each other, or windows, roof trusses, or walls? (immobilize or move chandeliers)
- ❑ ❑ *Are air distribution grills or diffusers securely mounted?* (provide anchorage)
- ❑ ❑ *Do large metal air distribution ducts, especially those suspended a few feet, have diagonal bracing?* (solution OE3) **(A/E)**
- ❑ ❑ Have heavy objects been removed from the tops of shelves? For 5 & 6 year olds, overhead objects are only 3 feet off the floor. (remove the objects) **(LS)**

## ELECTRICAL EQUIPMENT

- ❑ ❑ Are fluorescent light bulbs and lenses fastened securely? (solution EE1)
- ❑ ❑ Are emergency battery-powered lights fastened securely on shelves? (secure batteries)
- ❑ ❑ Is essential communications equipment secured? (secure it)

## MECHANICAL EQUIPMENT

- ❑ ❑ *Are the water heaters restrained?* (solution ME1)
- ❑ ❑ *Is the furnace or boiler restrained?* (solution EF8) **(A/E)**
- ❑ ❑ *Are there masonry incinerator chimneys on the school site that have not been reinforced?* (remove them) **(A/E) (LS)**

***(A/E) indicates an architect or engineer should be consulted. (LS) indicates a life safety hazard.***

***Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.***

*Use this checklist to complete a nonstructural hazards survey at a school site. Once the survey is completed, any checks in the NO boxes indicate items that are in need of correction.*

YES/NO

- ❑ ❑ *Are large diameter pipes braced or do pipes that cross expansion joints have accommodation for movement*? (solution ME2) **(A/E)**
- ❑ ❑ *Are fans, chillers, pumps, or other heating-ventilating-air conditioning equipment--typically found in mechanical rooms--restrained or mounted correctly*? (solution ME3a or b) **(A/E)**
- ❑ ❑ *Do the fire sprinkler risers have a v-brace to the wall, and do the large diameter sprinkler pipes have diagonal braces to the structure above*? (solution ME2) **(A/E)**

## PARTITIONS

- ❑ ❑ Are freestanding, movable, partial-height partitions--especially if supporting bookshelves--adequately braced? (solution PA1)
- ❑ ❑ Have all unreinforced masonry partitions, usually brick or hollow tile walls in pre-1933 buildings, been removed? (remove them) **(LS)**
- ❑ ❑ Are light-weight drywall partitions that extend as high as the hung ceiling braced or supported by the structure above, particularly if these partitions are used as lateral support for tall shelving or cabinets? (solution PA3) **(A/E)**
- ❑ ❑ Are the clear panels in partitions made of plastic or safety glass? (replace with shatter-proof material or apply shatter-resistant film)

YES/NO

## WINDOWS

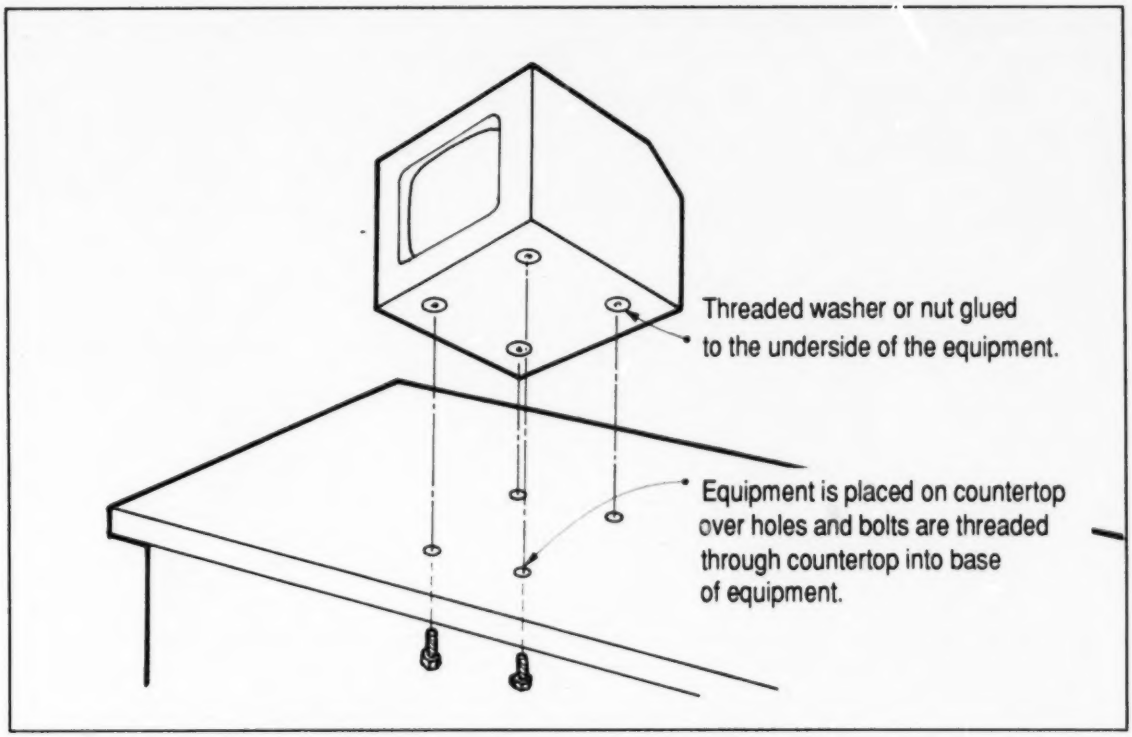
- ❑ ❑ *Are the large panes made of safety glass, and is it known if the mounting of the panes was designed by an architect/engineer to accommodate expected seismic distortion of the surrounding structure*? (apply shatter-resistant film)
- ❑ ❑ *Are transoms (glass panes over doors) of safety glass*? (apply shatter-resistant film)

## EXTERIORS

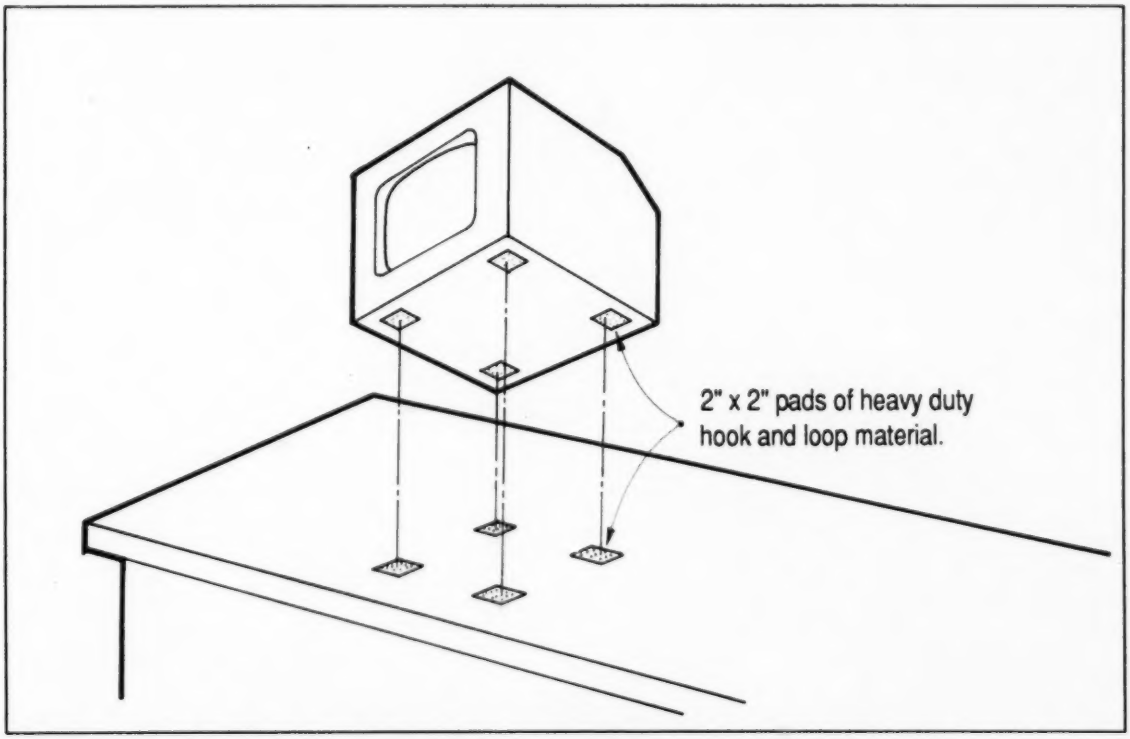
- ❑ ❑ Are decorations or appendages adequately attached? (solution E1) **(A/E)**
- ❑ ❑ Are statuary or decorative objects anchored? (solution E1) **(A/E)**
- ❑ ❑ Are tall backboards or fences supported by pressure-treated wood posts or galvanized metal posts? (provide anchorage to ground)
- ❑ ❑ *Are fences made of concrete, concrete block, stone or brick, adequately reinforced to resist earthquakes*? (reinforce or remove) **(A/E)**
- ❑ ❑ If large trees are leaning or in poor health are they supported? (support or remove trees)
- ❑ ❑ Is signage adequately secured, especially if heavy? (solution E1)

***(A/E) indicates an architect or engineer should be consulted. (LS) indicates a life safety hazard.***

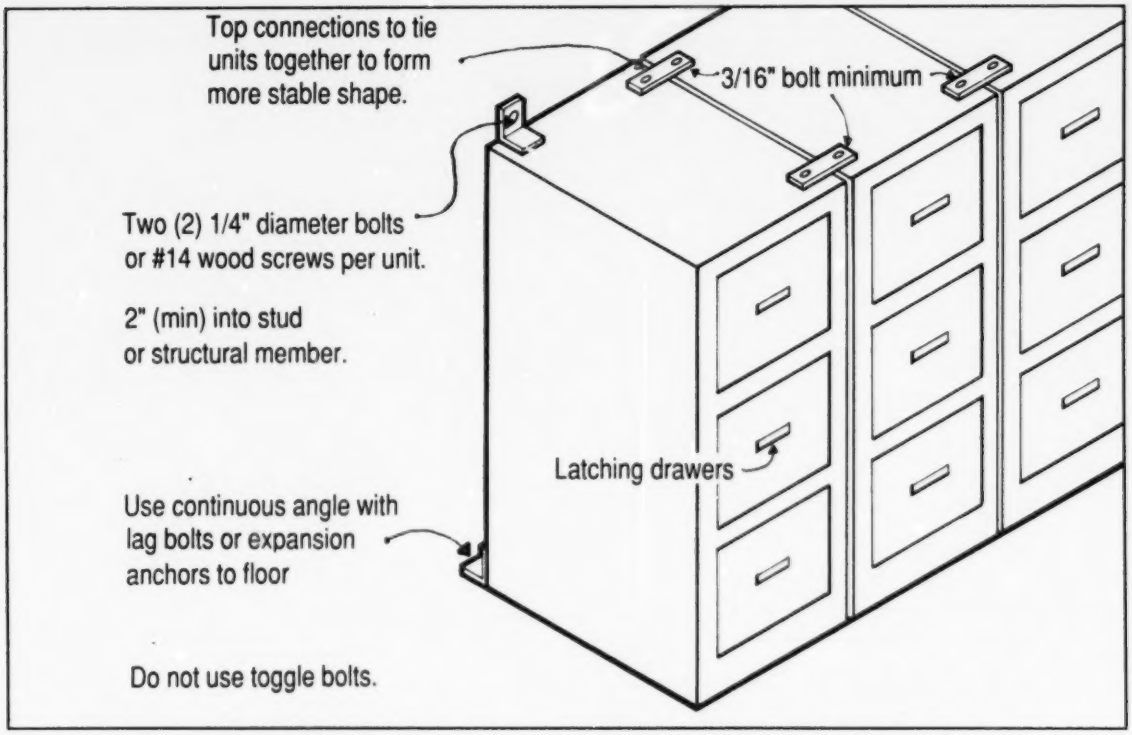
***Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.***


Threaded washer or nut glued
to the underside of the equipment.
Equipment is placed on countertop
over holes and bolts are threaded
through countertop into base
of equipment.

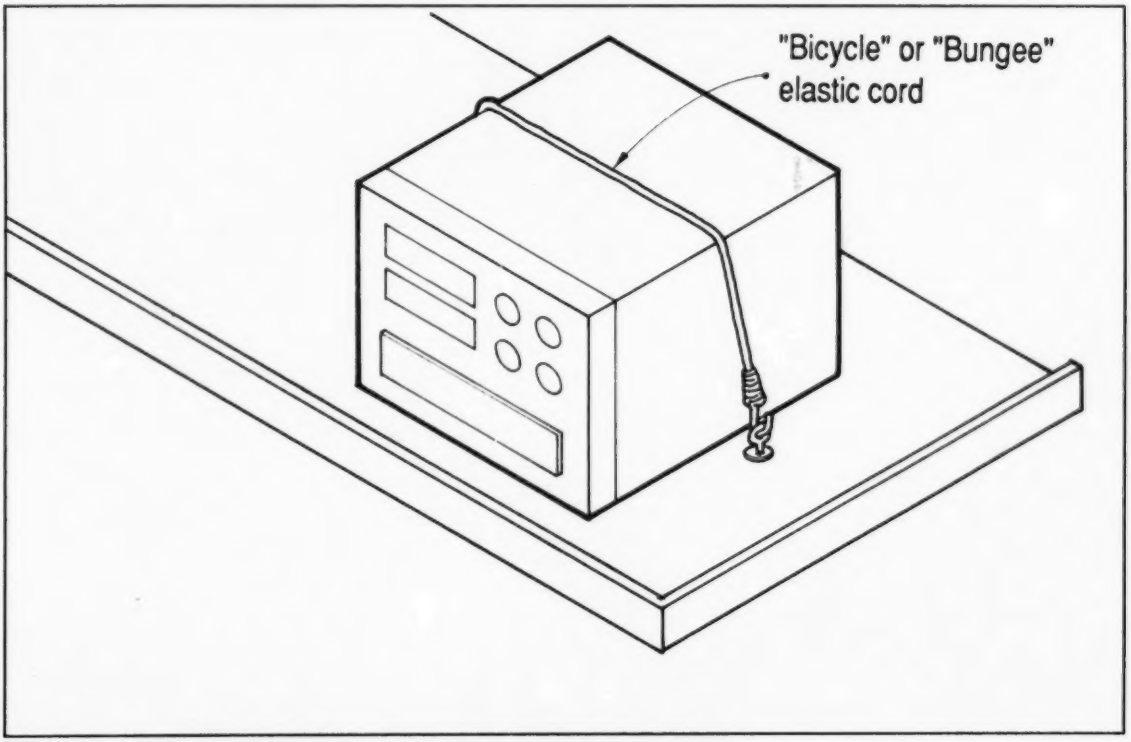
**EF1(a)** - FIXED ATTACHMENT OF EQUIPMENT TO COUNTERTOP



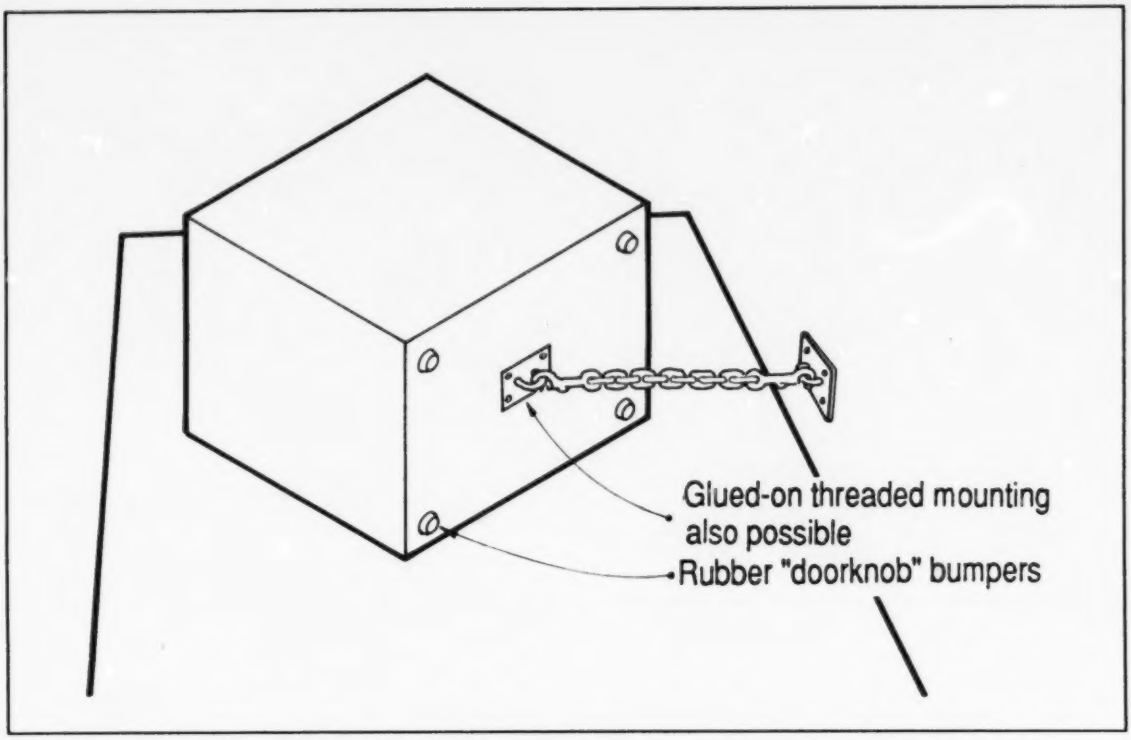

**EF1(b)** - REMOVABLE ATTACHMENT OF EQUIPMENT TO COUNTERTOP


Top connections to tie units together to form more stable shape.
3/16" bolt minimum
Two (2) 1/4" diameter bolts or #14 wood screws per unit.
2" (min) into stud or structural member.
Latching drawers
Use continuous angle with lag bolts or expansion anchors to floor
Do not use toggle bolts.

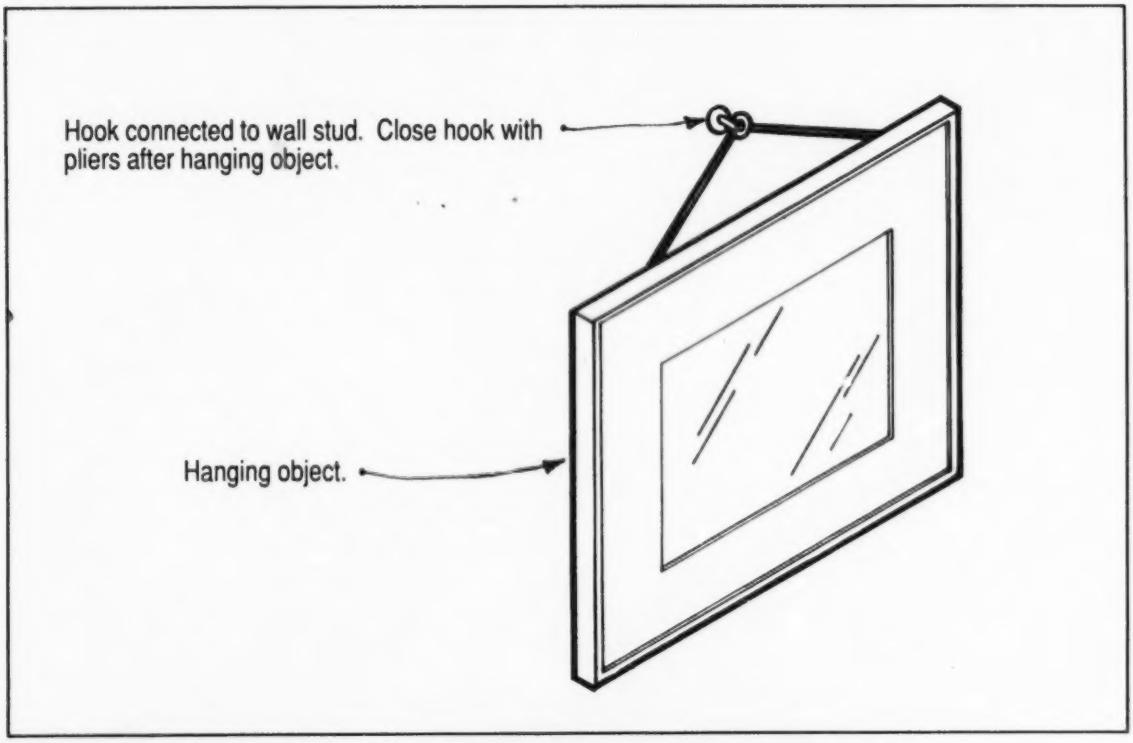
**EF2** - CABINETS ATTACHED AT TOP, BOTTOM AND SIDES TO STRUCTURE



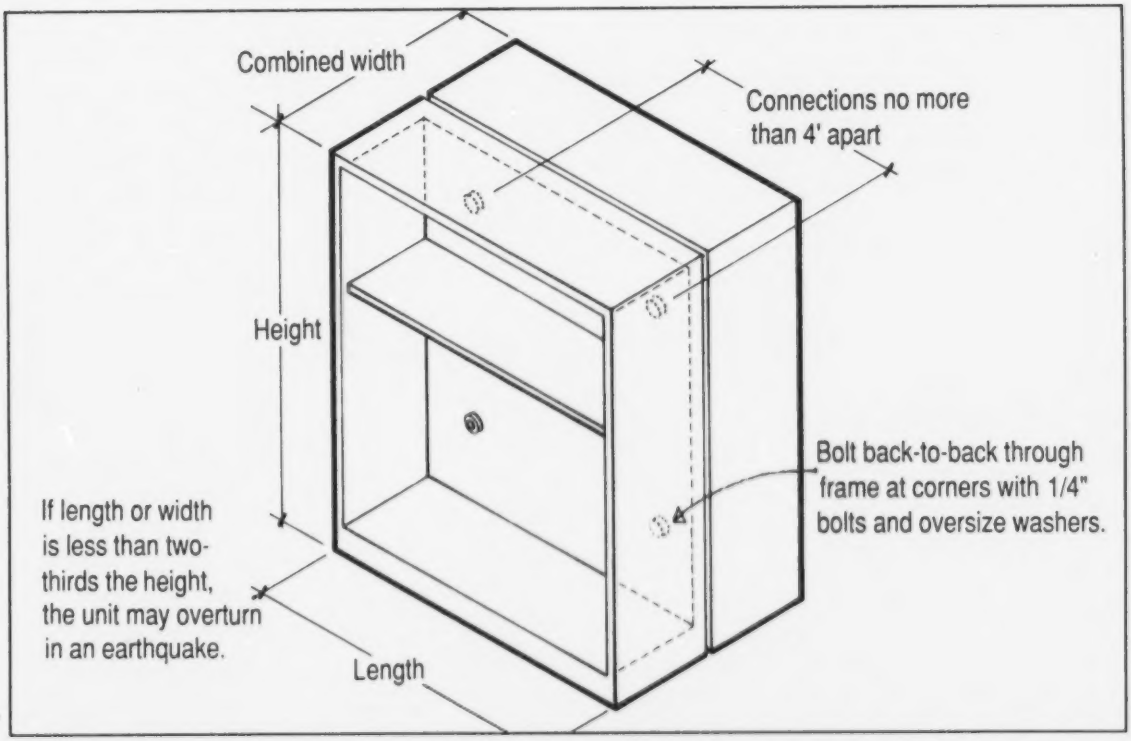

**EF3(a)** - TIE DOWN ATTACHMENT OF RADIO EQUIPMENT



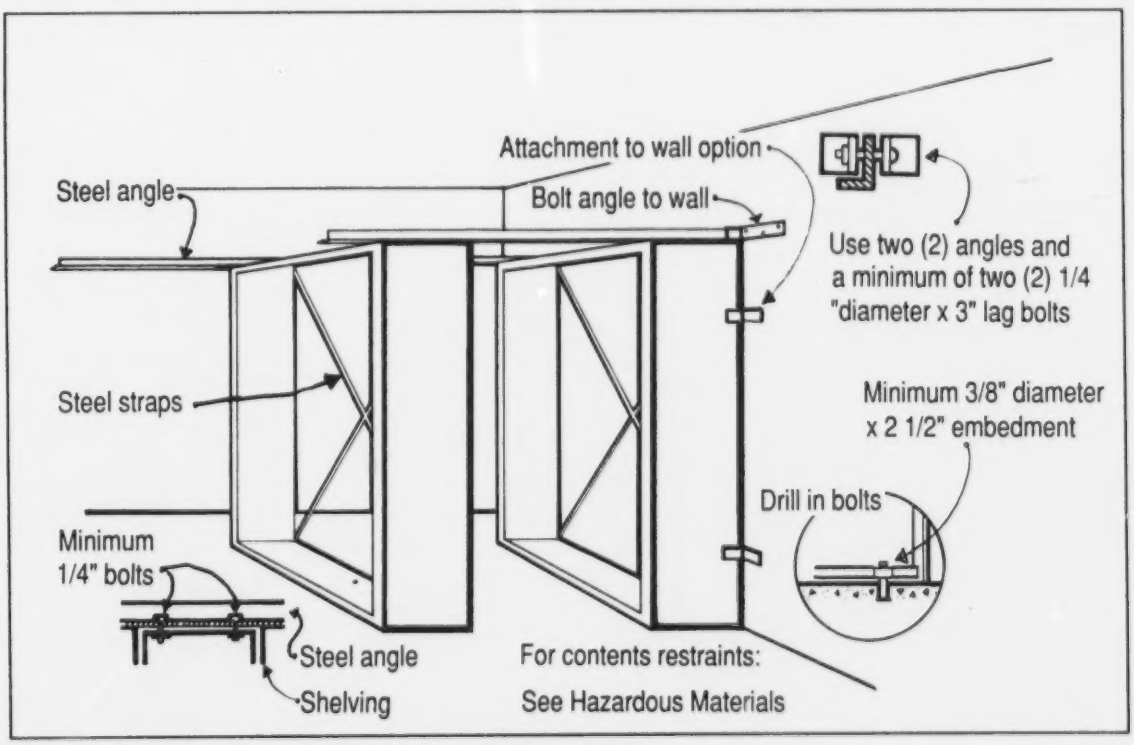

**EF3(b) -** DETACHABLE LEASH ATTACHMENT OF RADIO EQUIPMENT TO WALL



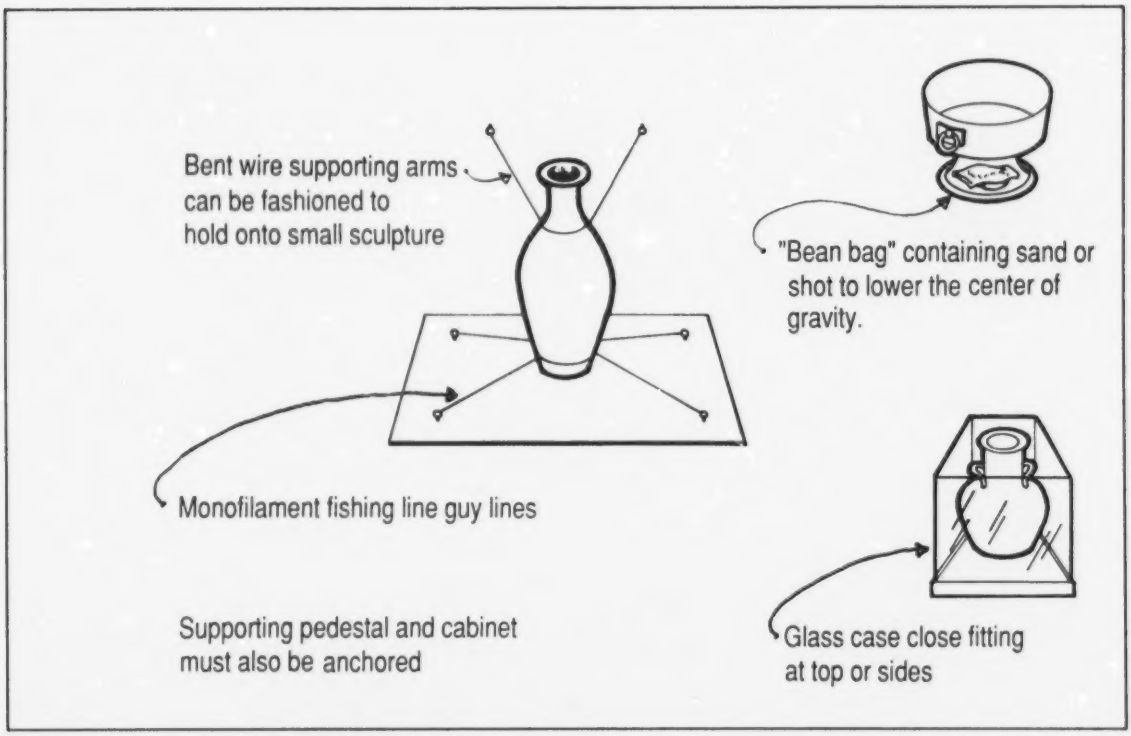

**EF4 -** ATTACHMENT OF SHELVES AND PICTURE FRAMES TO WALLS


Combined width
Connections no more than 4' apart
Height
Bolt back-to-back through frame at corners with 1/4" bolts and oversize washers.
If length or width is less than two-thirds the height, the unit may overturn in an earthquake.
Length

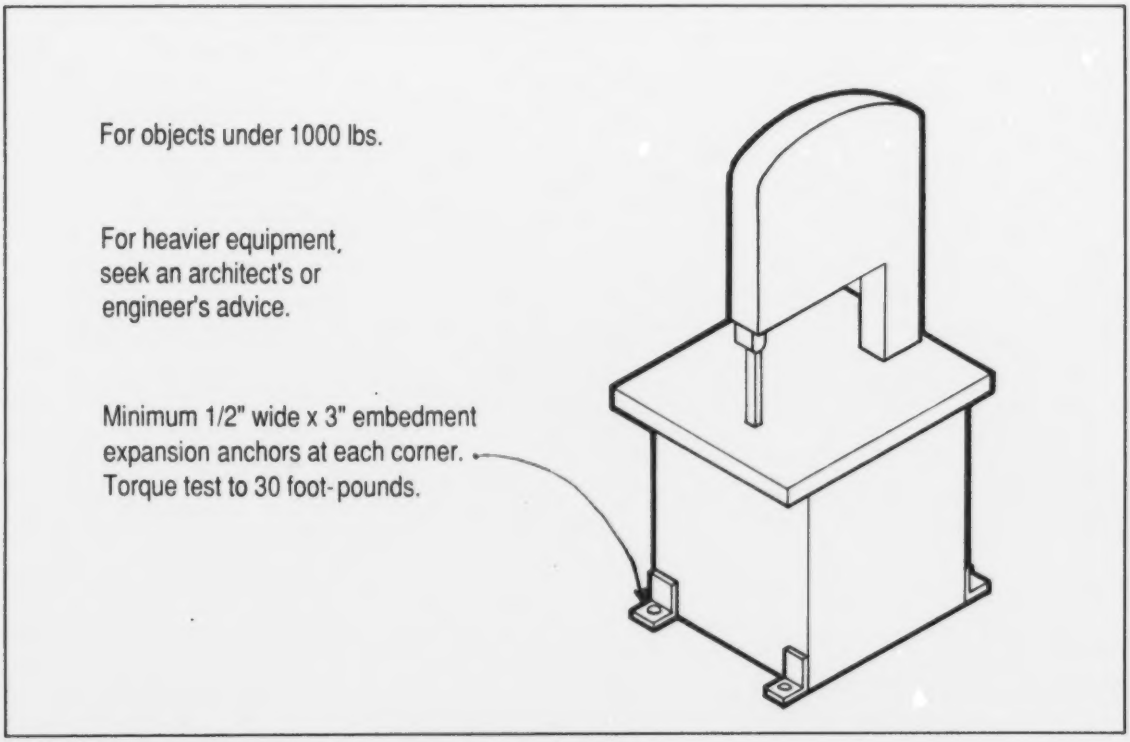
**EF5** - BACK-TO-BACK ATTACHMENT OF BOOKCASES TO PREVENT OVERTURNING


Attachment to wall option
Steel angle
Bolt angle to wall
Use two (2) angles and a minimum of two (2) 1/4 "diameter x 3" lag bolts
Steel straps
Minimum 3/8" diameter x 2 1/2" embedment
Drill in bolts
Minimum 1/4" bolts
Steel angle
Shelving
For contents restraints:
See Hazardous Materials

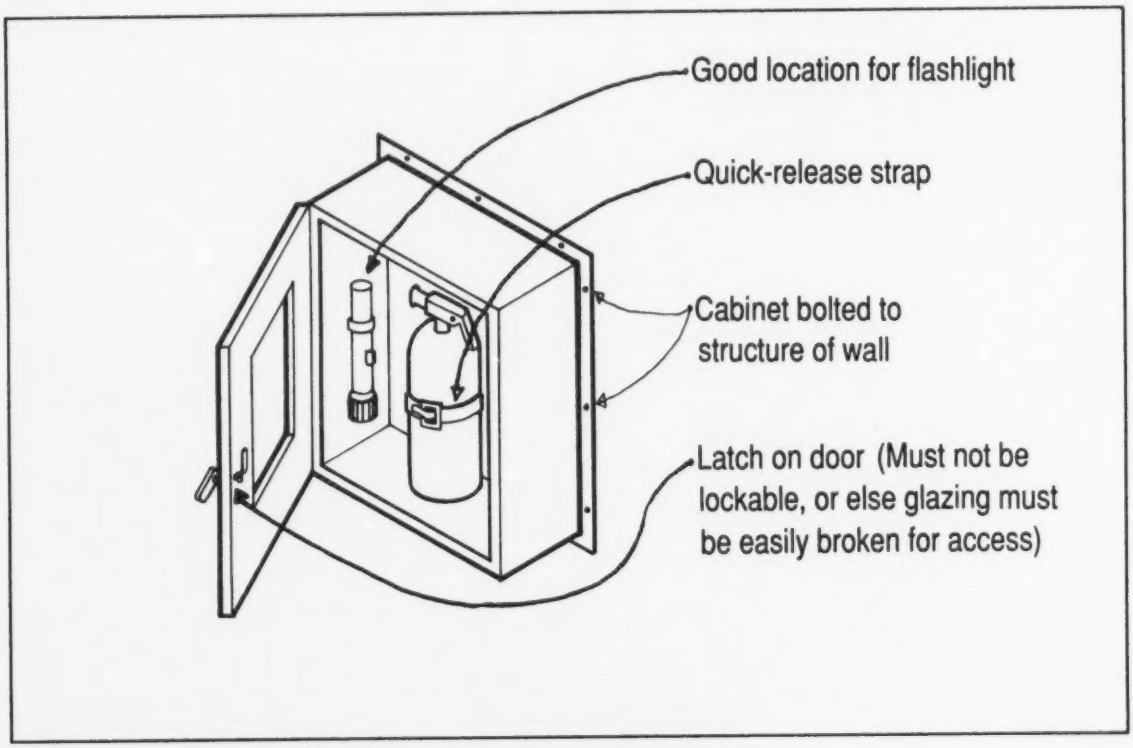
**EF6** - BRACING OF LIBRARY SHELVING (STACKS)


Bent wire supporting arms can be fashioned to hold onto small sculpture
"Bean bag" containing sand or shot to lower the center of gravity.
Monofilament fishing line guy lines
Supporting pedestal and cabinet must also be anchored
Glass case close fitting at top or sides

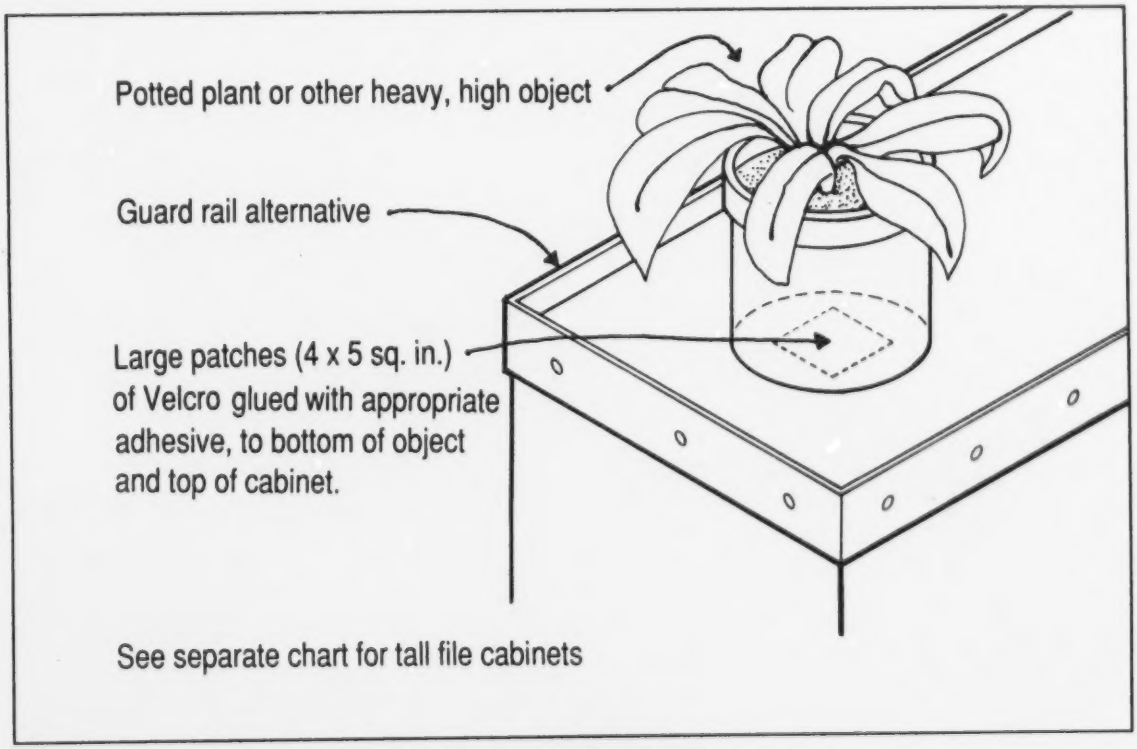
**EF7** - BRACING OF FRAGILE DISPLAYS


For objects under 1000 lbs.
For heavier equipment, seek an architect's or engineer's advice.
Minimum 1/2" wide x 3" embedment expansion anchors at each corner. Torque test to 30 foot-pounds.

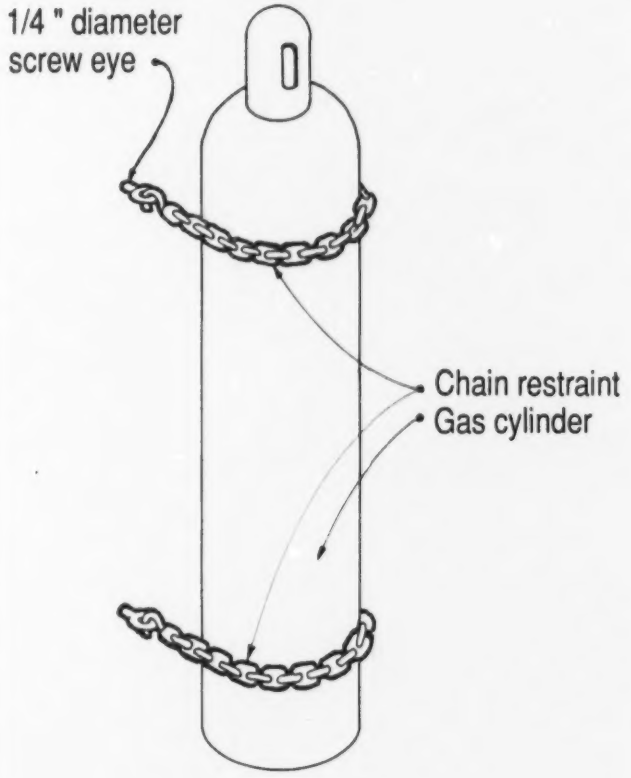
**EF8** - BOLTING OF SHOP EQUIPMENT TO FLOOR


Good location for flashlight
Quick-release strap
Cabinet bolted to structure of wall
Latch on door (Must not be lockable, or else glazing must be easily broken for access)

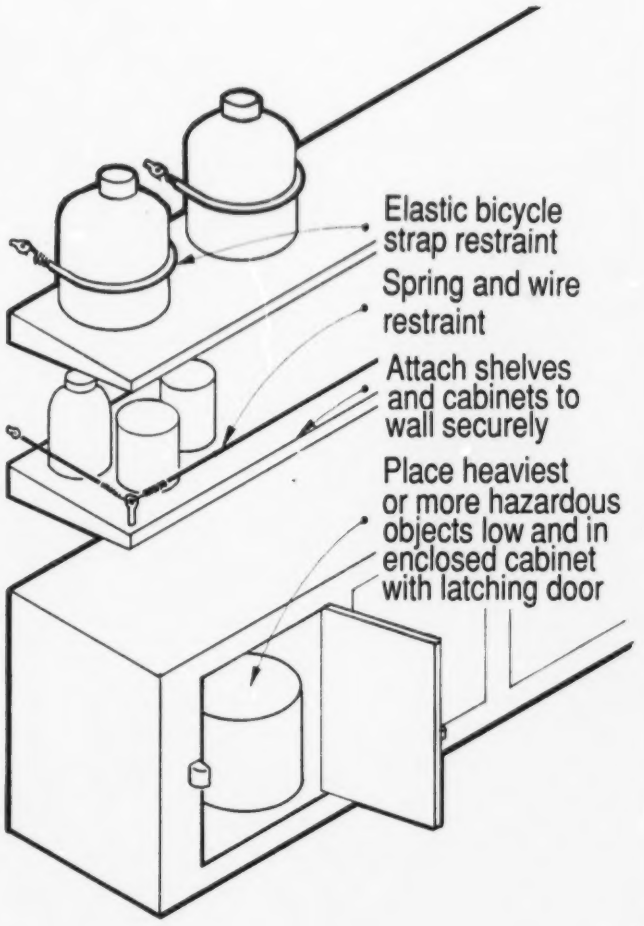
**EF9** - ATTACHMENT OF FIRE EXTINGUISHER TO WALL


Potted plant or other heavy, high object
Guard rail alternative
Large patches (4 x 5 sq. in.) of Velcro glued with appropriate adhesive, to bottom of object and top of cabinet.
See separate chart for tall file cabinets

**EF10** - GUARDRAILS TO CONTAIN FALLING OBJECTS

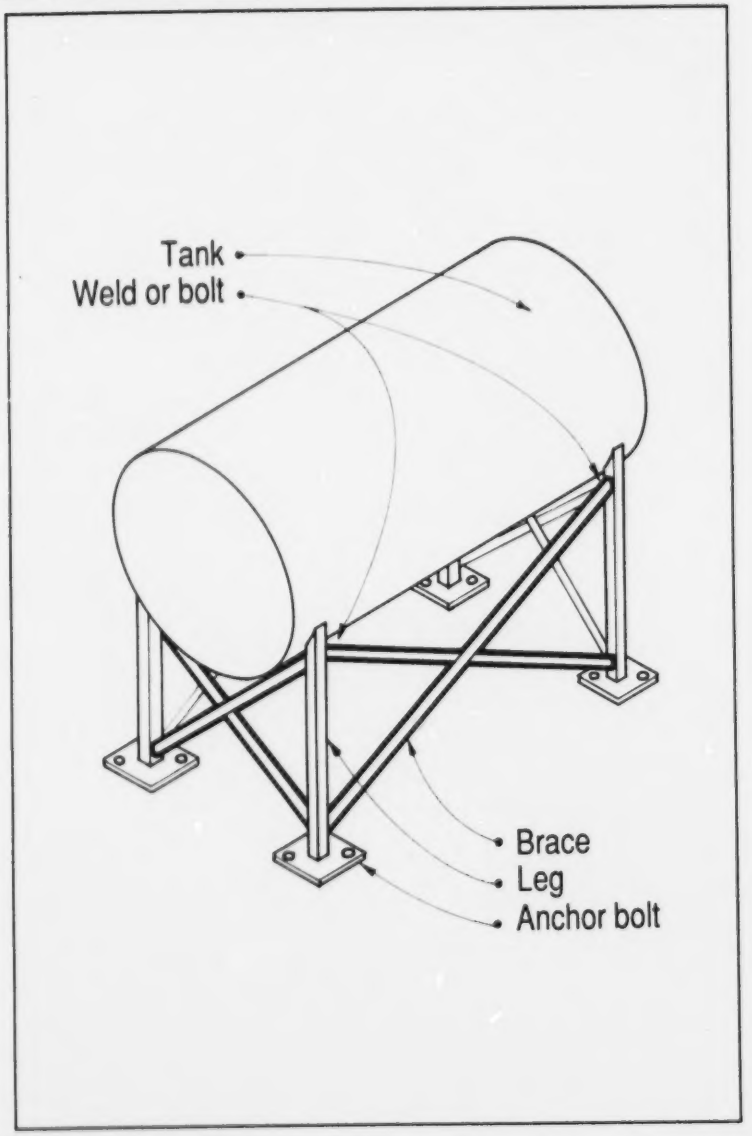



**HM1**-SAFETY CHAINS FOR BOTTLED HIGH PRESSURE GASES




**HM2**-SAFETY RESTRAINTS FOR CHEMICAL STORAGE

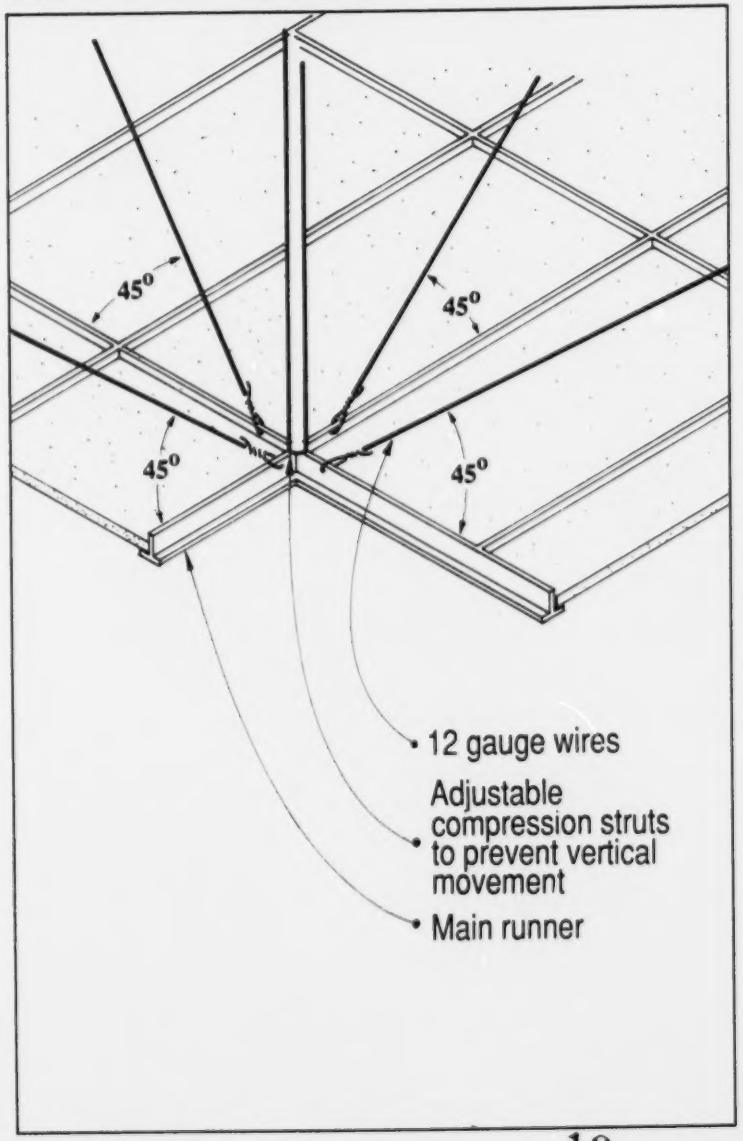
**HM3 -** SEISMIC BRACING FOR ELEVATED TANKS

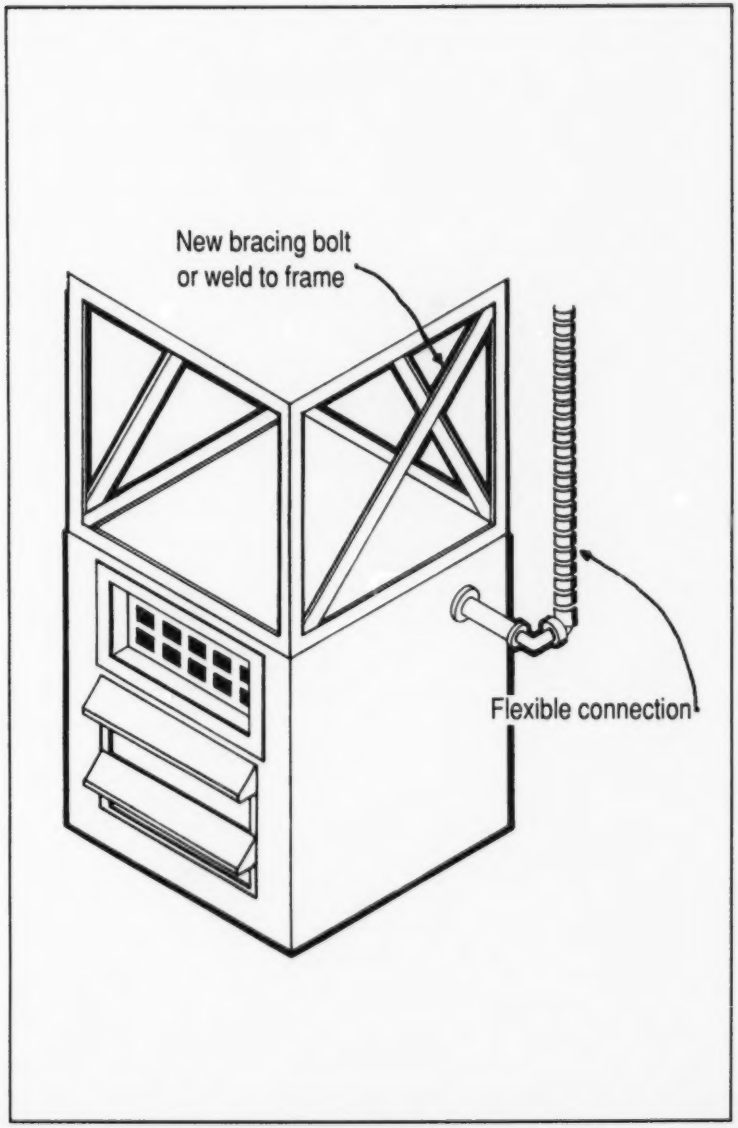






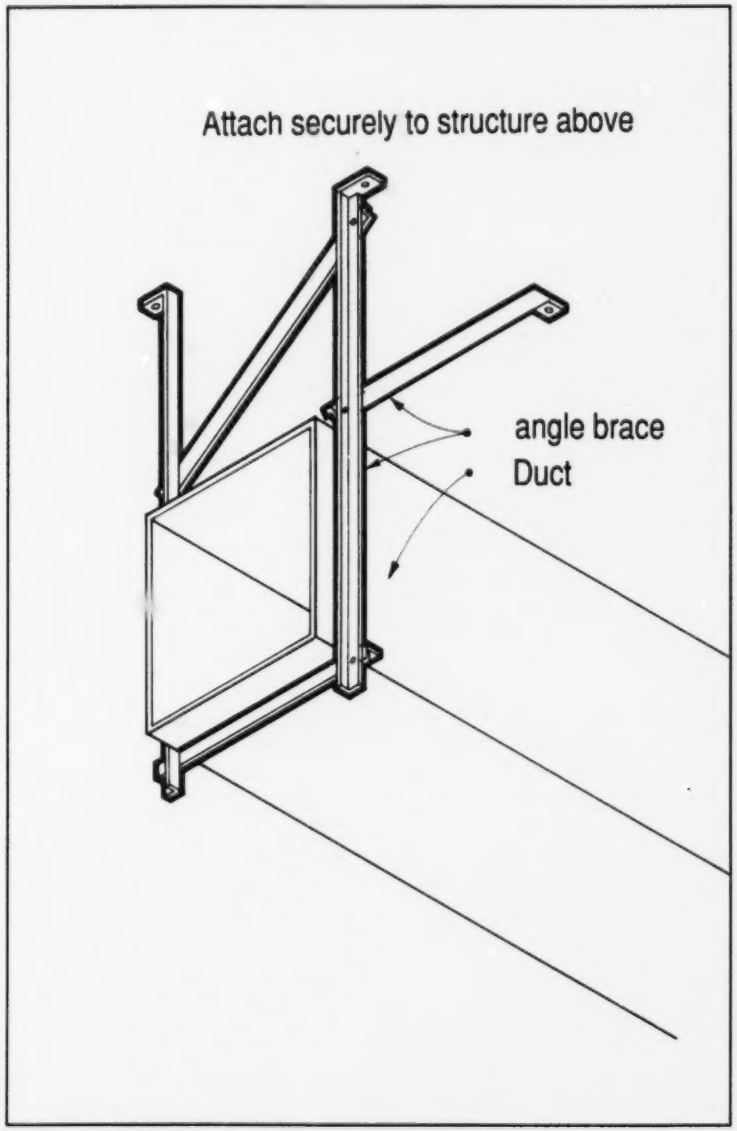

**OE1 -**SEISMIC BRACING FOR SUSPENDED CEILINGS





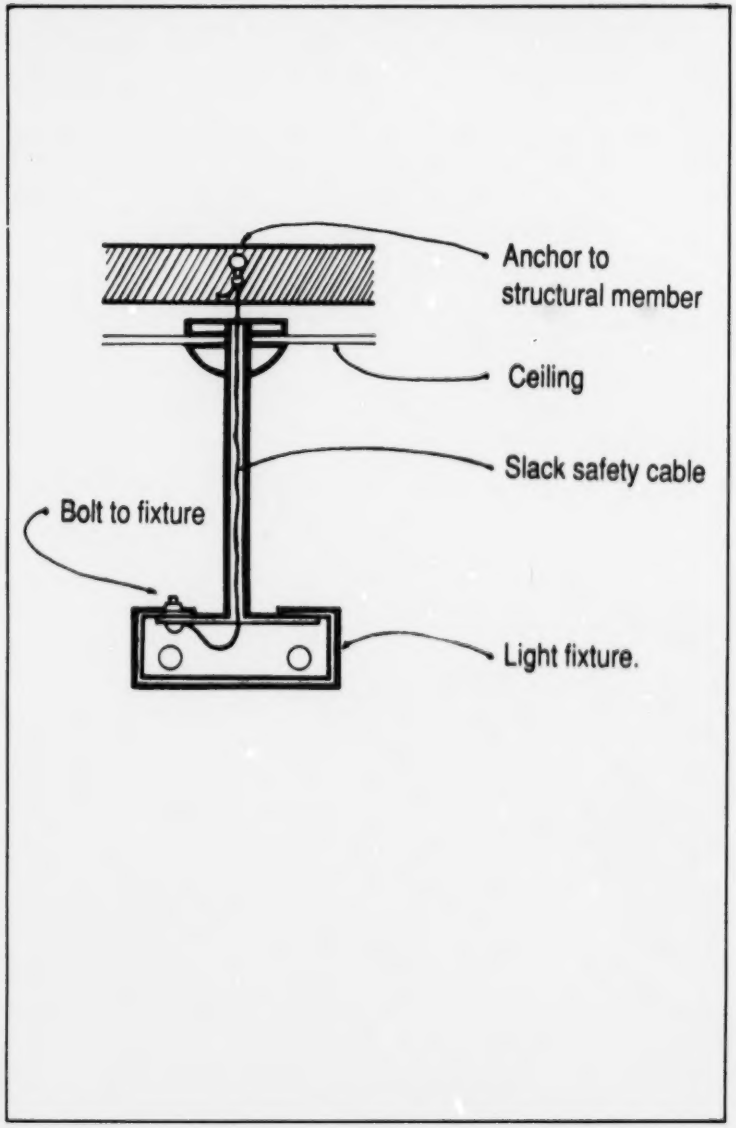

**OE2**- SEISMIC BRACING FOR SUSPENDED UNIT HEATERS






**OE3** - SEISMIC BRACING FOR HVAC DUCT

**OE4** - SAFETY WIRE FOR PENDANT LIGHT FIXTURE

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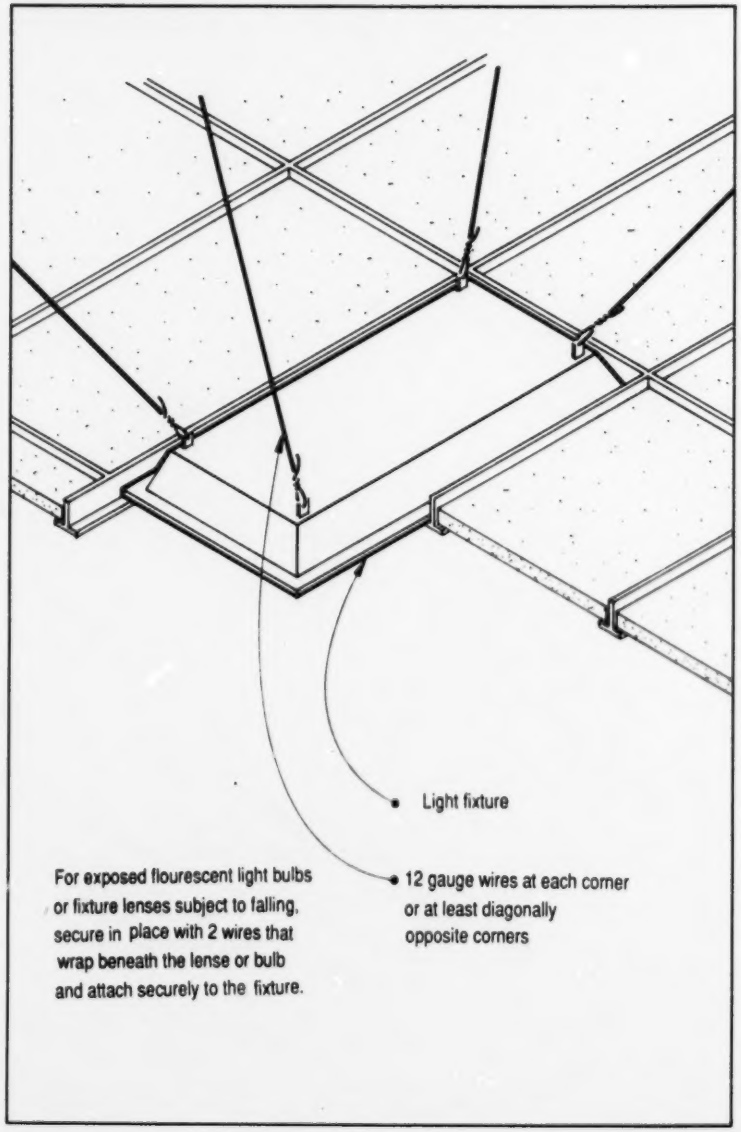
**EE1** - SEISMIC SAFETY WIRES FOR LIGHT FIXTURES


Light fixture
For exposed flourescent light bulbs or fixture lenses subject to falling, secure in place with 2 wires that wrap beneath the lense or bulb and attach securely to the fixture.
12 gauge wires at each corner or at least diagonally opposite corners

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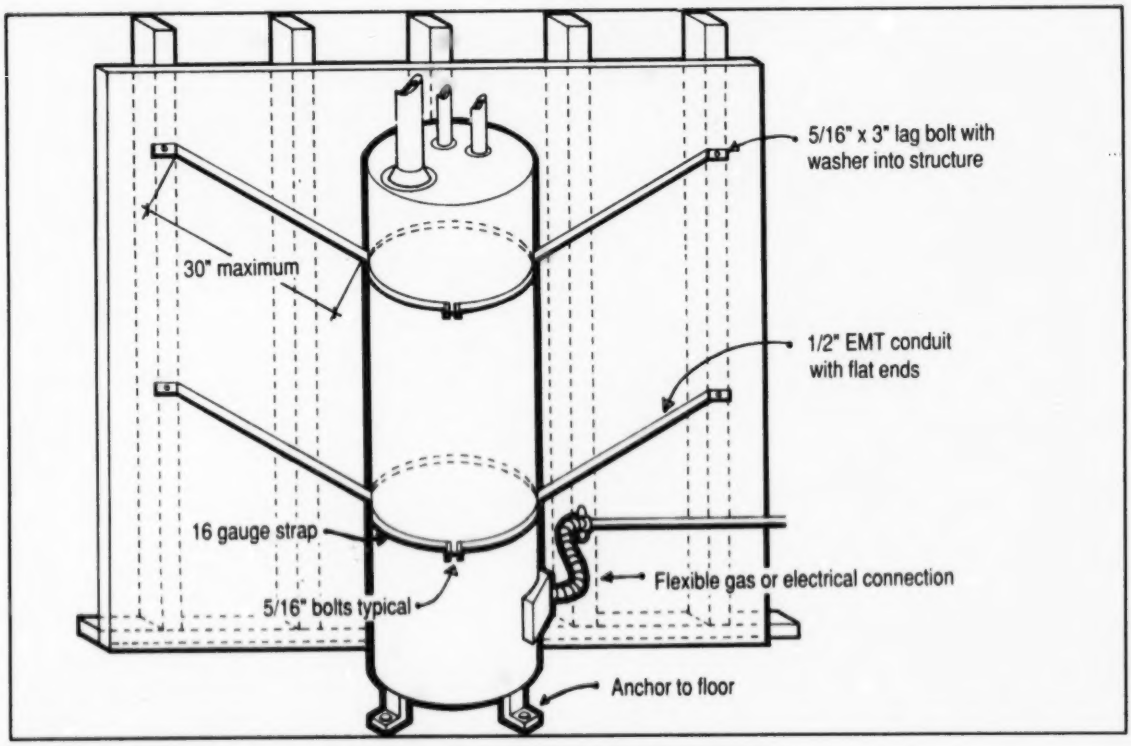
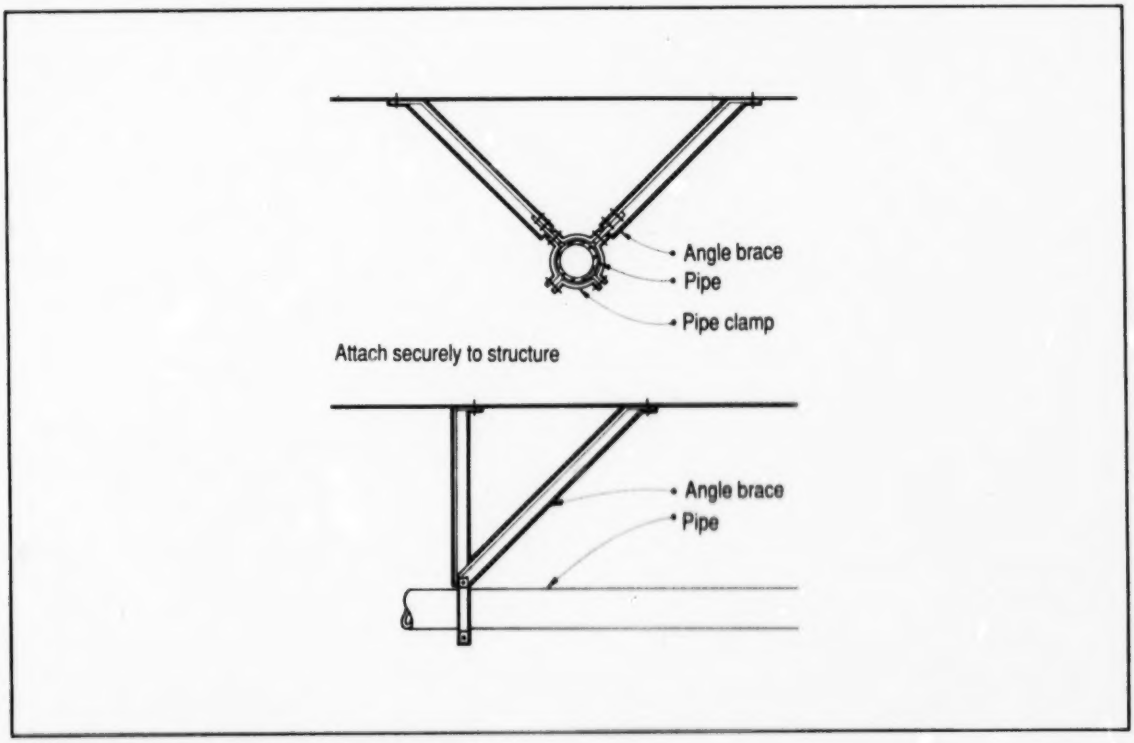
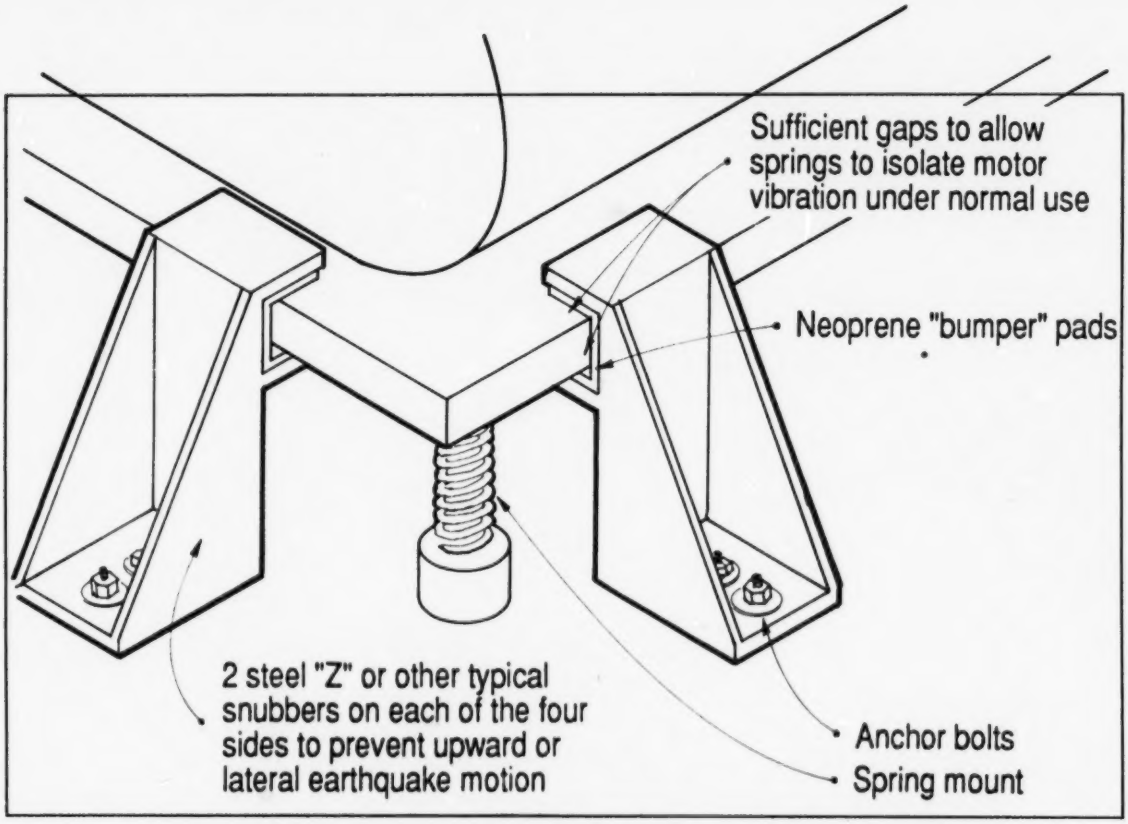


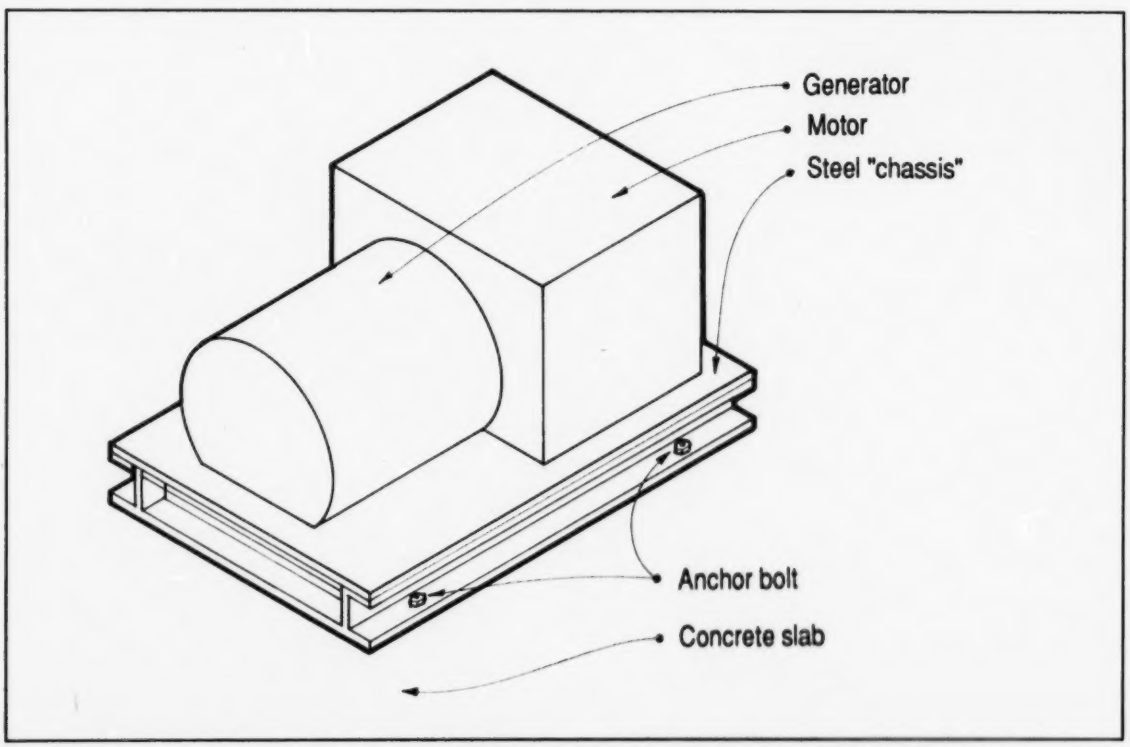

**ME1 - SEISMIC BRACE SYSTEM FOR HOTWATER HEATERS**



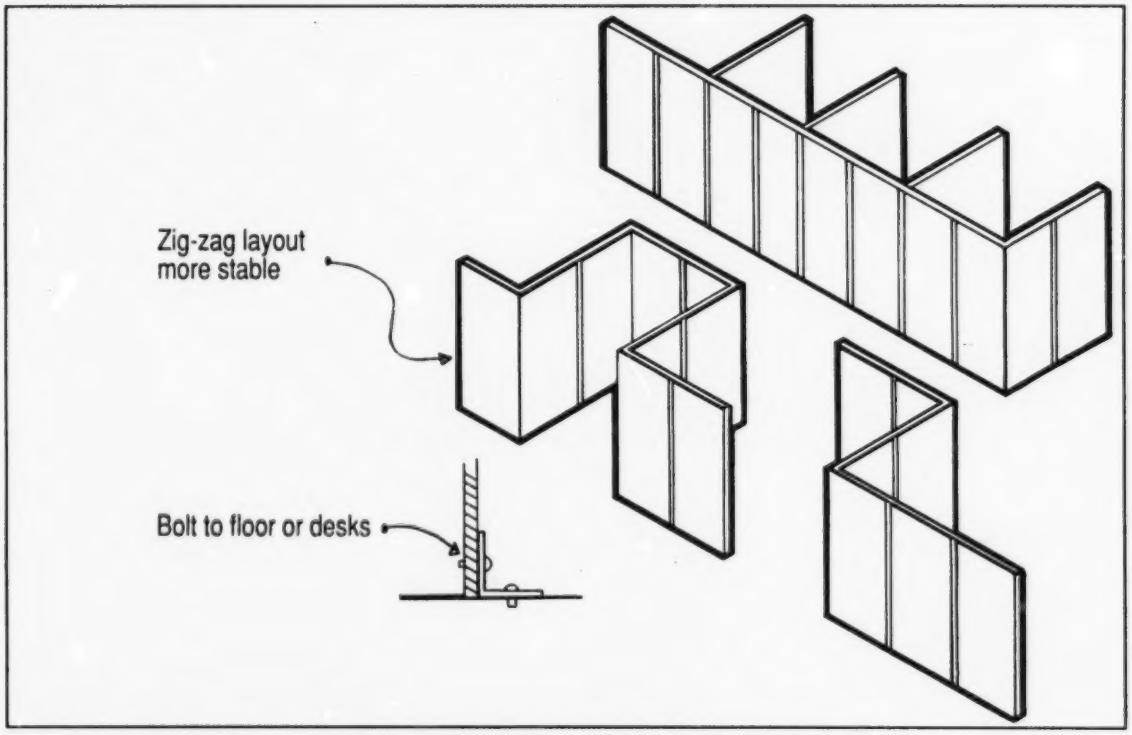

**ME2 - SEISMIC BRACING OF PIPING**


Sufficient gaps to allow springs to isolate motor vibration under normal use
Neoprene "bumper" pads
2 steel "Z" or other typical snubbers on each of the four sides to prevent upward or lateral earthquake motion
Anchor bolts
Spring mount

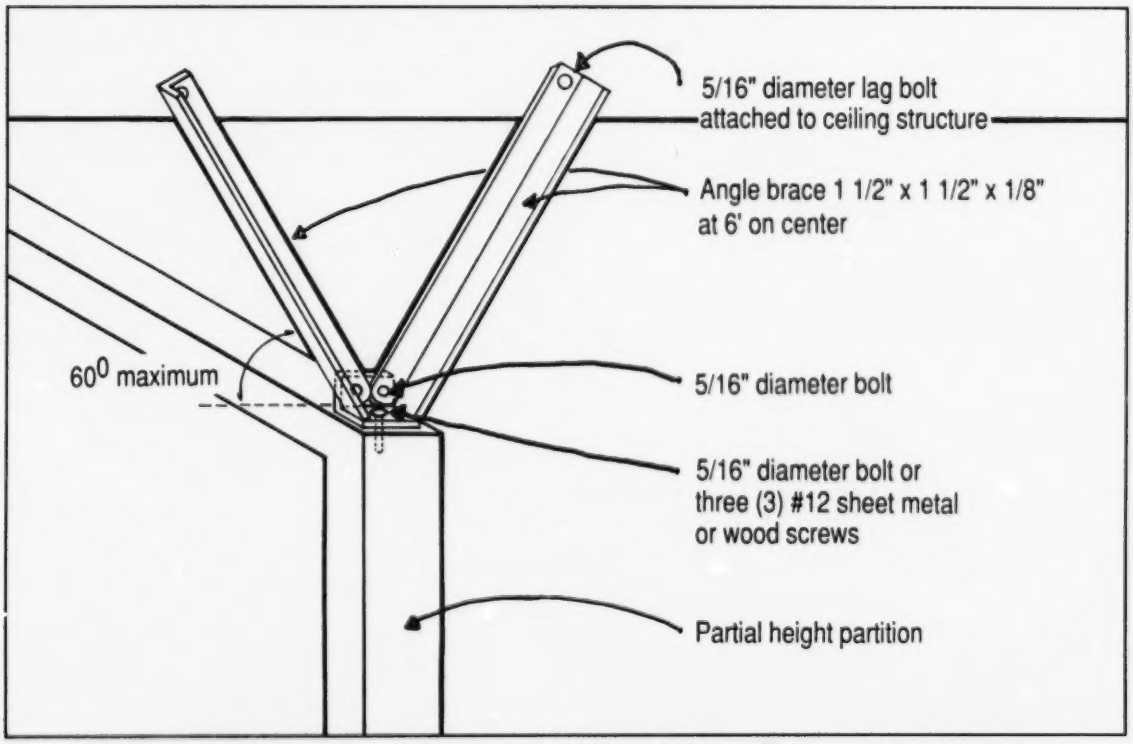
**ME3(a)** - SEISMIC SNUBBERS AND SPRING MOUNT FOR MECHANICAL EQUIPMENT



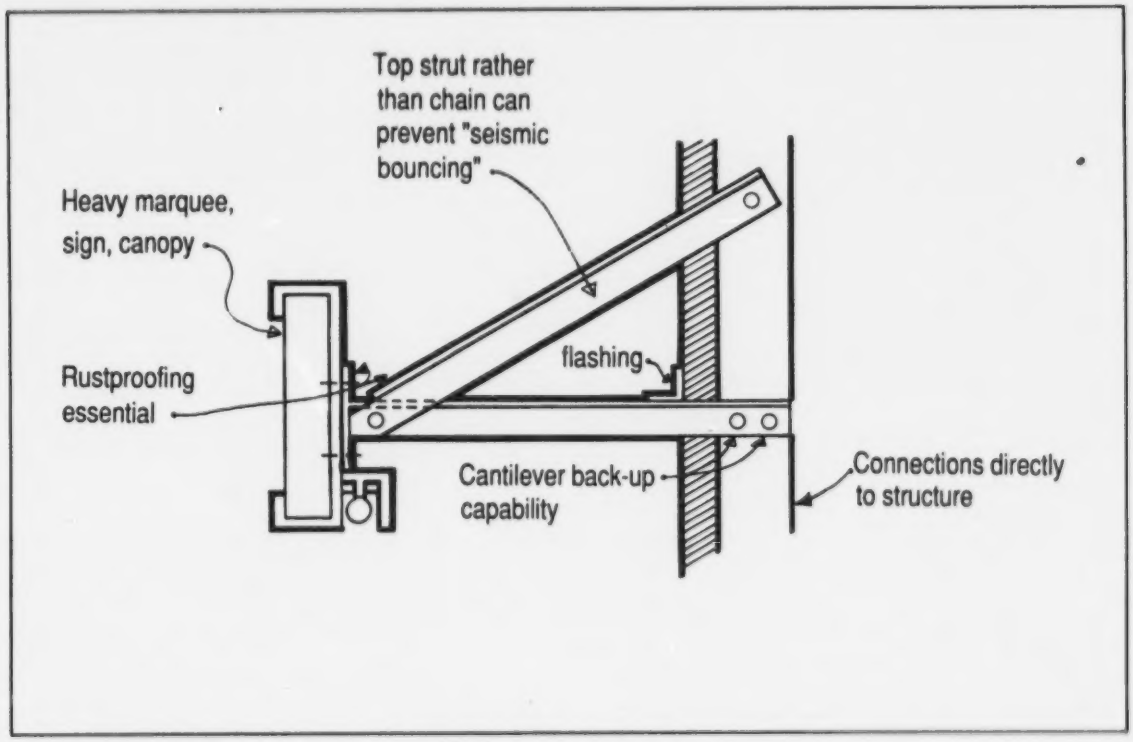

**ME3(b)** - ANCHOR BOLT AND CHASSIS SYTEM FOR MECHANICAL EQUIPMENT




**PA1** - INTERLOCKING ARRANGEMENT FOR SEISMIC STABILITY


5/16" diameter lag bolt
attached to ceiling structure
Angle brace 1 1/2" x 1 1/2" x 1/8"
at 6' on center
60⁰ maximum
5/16" diameter bolt
5/16" diameter bolt or
three (3) #12 sheet metal
or wood screws
Partial height partition

**PA2** - SEISMIC BRACING OF NON-STRUCTURAL PARTITIONS AND ROOM DIVIDERS




**E1 - BRACING OF CANTILEVERED MARQUEE OR SIGN**

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